

APPENDIX F:
CALCULATIONS IN SUPPORT OF WATER RESOURCES ANALYSIS

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F.1 MIXING MODEL

The principal type of calculation performed for this environmental impact statement (EIS) was a mixing calculation used to estimate upstream and downstream concentrations for the water quality parameters of interest (total dissolved solids [TDS], total suspended solids [TSS], biochemical oxygen demand [BOD], chemical oxygen demand [COD], selenium, and total phosphorus). This model was used for both the proposed action that would use a wet cooling system and the dry cooling alternative.

When two streams of water mix together to form a new stream, the following relationships can be used to estimate the properties of the new stream if the mass of water and mass of solute are conserved (Walski et al. 2001):

$$V_1 + V_2 = V_3 \quad (F.1)$$

and

$$V_1 C_1 + V_2 C_2 = V_3 C_3, \quad (F.2)$$

where V_1 , V_2 , and V_3 are the flows in streams 1 through 3, respectively, and C_1 , C_2 , and C_3 are the concentrations of a water quality parameter in streams 1 through 3, respectively. Equation F.1 expresses conservation of water mass, and Equation F.2 expresses conservation of the mass of solute.

Equations F.1 and F.2 can be combined to find the concentration of a water quality parameter in a stream as follows:

$$C_3 = \frac{C_1 V_1 + C_2 V_2}{V_1 + V_2}. \quad (F.3)$$

Equation F.3 assumes that streams 1 and 2 are both upstream of stream 3, with known flows and concentrations.

For the present analysis, it was first necessary to evaluate the conditions upstream of the power plants (i.e., water quality parameters were known at the Calxico gage and in discharge water from the Zaragoza Oxidation Lagoons but not known upstream of these two facilities). For this initialization, values for C_3 and V_3 and C_2 and V_2 were known, and those for C_1 and V_1 needed to be calculated. Flow V_1 was simply the difference between V_3 and V_2 ; that is:

$$V_1 = V_3 - V_2. \quad (F.4)$$

The unknown upstream water quality parameter, C_1 , was then evaluated, with the following expression derived from Equations F.1 and F.2:

$$C_1 = \frac{C_3V_3 + C_2V_2}{V_3 - V_2} . \quad (F.5)$$

For operation of a single power plant (either the La Rosita Power Complex or the Termoeléctrica de Mexicali plant), water quality parameters were estimated by using Equation F.5 for initial upstream conditions (Calexico gage and Zaragoza Oxidation Lagoons), followed by Equation F.3 for the initial condition and modified lagoons flow, and then followed by another calculation for the power plant and combined output of the initial conditions and lagoons. For both plants operating at the same time, Equation F.5 was first used to estimate the initial upstream conditions, and then Equation F.3 was sequentially applied for the Zaragoza Oxidation Lagoons and each of the power plants.

F.1.1 Salton Sea Salinity

The salinity of the Salton Sea was calculated as the mass of salt present divided by the volume of water in the Sea:

$$TDS = \frac{\text{Mass of salt}}{\text{Volume of Sea}} . \quad (F.6)$$

Changes in salinity for the Sea are a function of two processes: (1) a decrease in volume of the Sea because of water consumption by the power plants and (2) continued inflow of TDS to the Sea. The salinity of the Sea due to a reduction in volume was calculated with Equation F.6, using the modified Sea volume and a total mass of salt of 9.126×10^{11} lb (4.1×10^8 kg).

Because of the high rate of evaporation from the Sea (70.8 in./yr or 1.8 m/yr), the Sea would adapt to its new inflow quickly. The reduction in Sea volume can be represented by the following equation, which is a form of level-pool routing (Henderson 1966):

$$\frac{dV}{dt} = I - O , \quad (F.7)$$

where

I = inflow to the Sea,

O = outflow from the Sea (evaporation only),

t = time, and

V = volume of the Sea.

Integrating Equation F.7 and solving for time gives the following result:

$$\Delta t = \frac{\Delta V}{I - EA} , \quad (\text{F.8})$$

where E is the rate of evaporation from the Sea, A is its surface area, and ΔV is the change in volume of the Sea caused by plant operations. In actual practice, the area of the Sea changes with time, and the integration cannot be performed as easily. However, because the change in area is small relative to the initial area of the Sea, it can be considered to be independent of time.

Assuming that the Salton Sea is currently in a state of equilibrium (i.e., the annual evaporation is equal to the total yearly inflow), a more accurate value for the rate of evaporation is 5.724 ft/yr (1.744 m/yr). At this rate, Equation F.8 predicts that the volume of the Sea would adjust to its new value for both plants operating in a time period of 1 year. This calculation assumes an annual average inflow to the Sea of 1,329,333 ac-ft ($1.64 \times 10^9 \text{ m}^3$) for both plants operating 100% of the time and a surface area for the Sea of 234,113 acres (94,780 ha).

The second component contributing to the salinity of the Sea is continued inflow of salt. The continued salt inflow acts as a source for further salinization. The rate of salinization of the Sea was estimated by using an initial TDS load of 4.6×10^6 tons/yr (9.2×10^9 lb/yr) and an initial volume of the Sea equal to 7,624,843 ac-ft ($9.4 \times 10^9 \text{ m}^3$); all of the salinity entering the Sea was assumed to add to its TDS. The rate of increase is then given by the expression:

$$\Delta \text{TDS} = \frac{\text{TDS inflow load}}{\text{Volume of Sea}} . \quad (\text{F.9})$$

For the above initial conditions, the rate of salinity increase for the Sea is about 444 mg/L/yr.

Impacts of plant operations on the rate of salinization were then analyzed by using new Sea volumes based on plant operations and reduced salinity loads from the New River. The combined processes of volumetric reduction and continued salinization were then evaluated for conditions specific to the two power plants, and a final TDS was calculated for 1 year of plant operations.

F.1.2 Time to Achieve 60,000 mg/L for the Salton Sea

The time needed for the Salton Sea to increase its TDS from an initial value to 60,000 mg/L was calculated with the following expression:

$$\text{Time} = \frac{60,000 - \text{Initial concentration}}{\text{Salinization rate}} . \quad (\text{F.10})$$

The time in Equation F.10 is in years for a salinization rate in mg/L/yr and an initial TDS in mg/L.

F.2 REFERENCES

Henderson, F.M., 1966, *Open Channel Flow*, Macmillan Publishing Co., Inc., New York, N.Y.

Walski, T.M., et al., 2001, *Haestad Methods Water Distribution Modeling*, Haestad Press, Waterbury, Conn.